(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 0 961 432 A2

(12) EUROPEAN PATENT APPLICATION

(43) Date of publication:
01.12.1999 Bulletin 1999/48

(51) Int Cl.[6]: **H04H 1/00**

(21) Application number: **99304216.7**

(22) Date of filing: **28.05.1999**

(84) Designated Contracting States:
AT BE CH CY DE DK ES FI FR GB GR IE IT LI LU MC NL PT SE
Designated Extension States:
AL LT LV MK RO SI

(30) Priority: **28.05.1998 JP 16418598**

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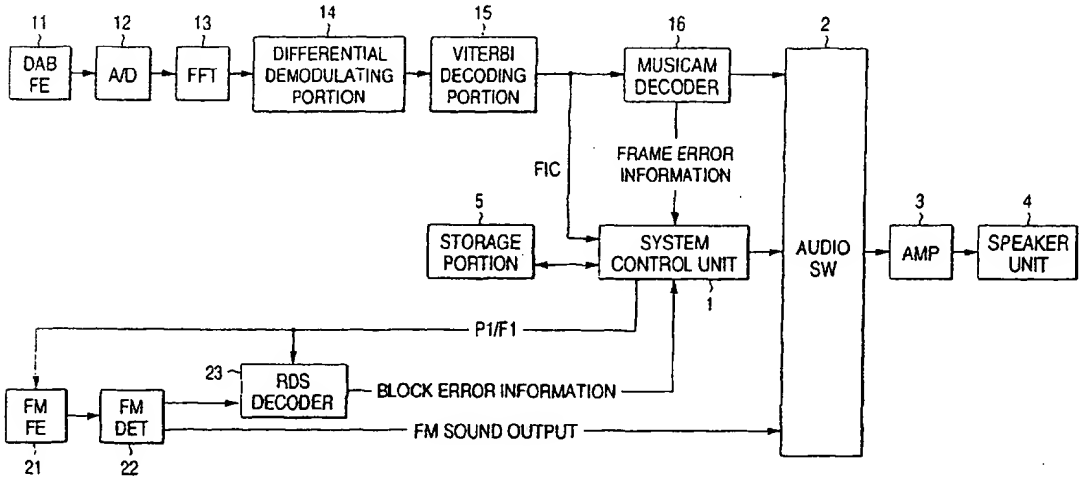
(54) Receiver for receiving Digital Audio Broadcast (DAB) programmes which have a plurality of protection levels

(57) Protection level information is extracted from a DAB received signal, a reference value corresponding to extracted protection level information is decided, and then a state in which the DAB received signal has been received is determined in accordance with the reference value and the DAB received signal.

FIG. 1



EP 0 961 432 A2

Description

[0001] The present invention relates to a digital broadcast receiver, and more particularly to a receiver for receiving digital audio broadcasting (hereinafter called "DAB") which has been put into practical use in Europe.

[0002] As a system for transmitting broadcast wave containing data signals which include digital audio signals and which are formed into a predetermined format and receiving the same, DAB system conforming to Europe Standard (Eureka 147) is known. The DAB incorporates one ensemble which is composed of a plurality of services. Each service is composed of a plurality of components including English and German.

[0003] Fig. 7 shows an example of services of the DAB system such that linking is illustrated which is established among services (three in this case) and components (six in this case) constituting an ensemble 1 and an OFDM signal actually transmitted from a DAB station.

[0004] The OFDM signal which is transmitted from the DAB station includes FIC (Fast Information Channel) and MSC (Main Service Channel).

[0005] Each of sub-channels (SubCh 0 to SubCh 63) for constituting the MSC corresponds to each component. The FIC contains information about services which can be used by the ensemble and information about the linkage among the services, components and sub-channels.

[0006] Therefore, in the DAB, when a certain ensemble has been received, information about a plurality of services and components included in the ensemble can be obtained. Thus, switch to another service or component can instantaneously be performed without a necessity of changing the receiving frequency.

[0007] As one of methods of using a DAB receiver for receiving the foregoing broadcast, a service following function with respect to an FM station which presents the same program. The foregoing function will now be described. The DAB enables information about the FM station which broadcasts the program which is the same as that which is being broadcast to be contained in a variety of information data items contained in the FIC. Information above includes identification information and information about the frequency of the FM station which broadcasts the same program.

[0008] Therefore, when the information items are obtained from the FIC obtainable from the DAB station which is being received to control the RDS receiver in accordance with the information item, tuning in to the FM station which is broadcasting the same program can easily be performed.

[0009] Therefore, a state of reception of the DAB station which is being received and that of the tuned FM station are subjected to a comparison. If the state of reception of the DAB station deteriorates, the reproduction output is switched to the audio output of the FM station which is broadcasting the same station (that is, service follow is performed). Thus, a satisfactory reproduced sound can be maintained.

[0010] On the other hand, the DAB is able to specify the bit rate of audio information for each sub-channel and the protection levels (1 to 5) of the transmission.

[0011] The protection level indicates resistance against a transmission error (since the coding rate is raised as the figure is enlarged, redundancy is reduced and thus resistance against an error is lowered). The coding rate is determined by performing convolution-coding and extracting (puncturing) a portion of coded signals in accordance with the protection level. Note that the DAB is regulated to have an average code rate of 0.34 to 0.75, the average code rate being obtained from the bit rate of audio information and the protection level. Also the foregoing information item is transmitted through the FIC.

[0012] A case will now be considered in which only a parameter, for example, an error rate, is used to determine the state of reception of the DAB station without any consideration of the protection level of audio information. In the foregoing case, there arises a problem in that the annoyance of heard noise varies depending on the protection level if the error rate is the same. When a comparison is made between a program having a high protection level and that having a low protection level, the annoyance of heard noise in the program having the high protection level is impaired if the error rate is the same. As a result, the detecting accuracies of the receiving state disperse considerably. Therefore, there arises a problem in that the annoyance of heard noise realized when the service follow is switched varies depending on the protection level of the selected service.

[0013] In view of the foregoing, an object of the present invention is to reflect the annoyance of heard noise on the reference value for use to evaluate a state of reception of a reproduced output.

[0014] According to a first aspect of the present invention, there is provided a digital broadcast receiver for receiving a digital audio broadcast which has a plurality of protection levels and which is able to vary a coding rate of a signal to be transmitted to correspond to each protection level and transmit at least protection level information together with digital audio information, the digital broadcast receiver comprising: a structure that protection level information is extracted from a received signal, a reference value corresponding to extracted protection level information is decided, and then a state of reception of the received signal is determined in accordance with the reference value and the received signal.

[0015] According to a second aspect of the present invention, there is provided a digital broadcast receiver according to the first aspect of the invention, further comprising a table for making plural reference values and plural protection levels to correspond to one another, wherein one certain reference value is selected from the table in accordance with extracted protection level information.

[0016] According to a third aspect of the present, there is provided a digital broadcast receiver according to the first or second aspect of the invention, wherein the digital audio broadcast is able to furthermore transmit audio bit-rate information of digital audio information, audio bit-rate information is extracted from the received signal, and also extracted bit rate information is used to decide the reference value.

[0017] According to a fourth aspect of the present invention, there is provided a digital broadcast receiver according to the third aspect of the invention, further comprising a table for making plural reference values, plural protection levels and plural audio bit-rate information items to correspond to one another, wherein one certain reference value is selected from the table in accordance with extracted protection level information and audio bit-rate information.

[0018] According to a fifth aspect of the present invention, there is provided a digital broadcast receiver comprising: an FM receiving portion incorporating an RDS decoder; a DAB receiving portion; and a control unit for performing control such that an output of the receiving portion in a superior state of reception is selected as an output of the digital broadcast receiver in accordance with a state of reception of an FM signal received by the FM receiving portion and a DAB signal received by the DAB receiving portion, wherein the control unit incorporates extracting means for extracting at least protection level information from the received DAB signal, and a state of reception of the DAB signal is determined in accordance with extracted protection level information and the received DAB signal.

[0019] In the drawings:-

Fig. 1 is a block diagram showing a digital broadcast receiver incorporating an RDS receiving portion according to a first embodiment of the present invention;

Fig. 2 is a flow chart which is executed by a system control unit 1;

Fig. 3 shows a table constituted in a storage portion 5;

Figs. 4A and 4B are diagrams for making a comparison between DAB data and RDS data;

Fig. 5 is a block diagram showing a digital broadcast receiver according to a second embodiment of the present invention;

Fig. 6 is a diagram showing a table constituted in the storage portion 5; and

Fig. 7 is a diagram showing an example of a service of a DAB system.

[0020] Now, a description will be given in more detail of preferred embodiments of the present invention with reference to the accompanying drawings.

(First Embodiment)

[0021] Embodiments of the present invention will now be described with reference to the drawings. Fig. 1 is a block diagram showing a digital broadcast receiver according to a first embodiment of the present invention and incorporating an RDS receiving portion. The receiver incorporates a DAB receiving portion for receiving a digital broadcast, an FM receiving portion for receiving an RDS broadcast, a system control unit 1, a switching portion 2, an amplifier 3, a speaker unit 4 and a storage portion 5.

[0022] The DAB receiving portion incorporates a DAB-FE (a front end for the DAB) 11 for tuning in to a DAB station; an A/D converter 12 for converting a received analog signal into a digital signal; an FFT (Fast Fourier Transformation) portion 13 for demodulating an OFDM wave; a difference demodulating portion 14 for demodulating difference modulation; a viterbi decoding portion 15 for correcting an error; and a musicam decoder 16 for decoding compressed musical data to original audio data. Since the specific structure of each element has been disclosed in a variety of document, detailed description is omitted here. The musicam decoder 16 outputs, to the system control unit 1, frame error information about an error of an audio frame of received data.

[0023] The FM receiving portion incorporates an FM-FE (a front end for the FM) 21 for tuning in to an FM station; an FM detector 22 for amplifying an intermediate-frequency (IF) signal to detect a composite signal in the amplified signal; and an RDS decoder 23 for extracting an RDS signal from the composite signal to demodulate the RDS signal. Also the foregoing structure has been disclosed in a variety of documents. Therefore, they are omitted from description. Similarly to the DAB receiving portion, the FM receiving portion outputs, to the system control unit 1, block error information about a block error of received RDS data.

[0024] The system control unit 1 controls the DAB receiving portion and the FM receiving portion. Moreover, the system control unit 1 reads the foregoing FIC information item from the DAB receiving portion to store a variety of information data items contained in read data in the storage portion 5. Information to be stored includes information about services which can be used by an ensemble, information about the linkage among the services, components and sub-channels and information (a PI code, an FI (frequency information) list) about FM stations. The system control unit 1 enables the FM receiving portion to quickly detect a candidate of the service follow by outputting read PI code information and FI list information to the FM-FE portion 21 and the RDS decoder 23.

[0025] The system control unit 1 controls the switching portion 2. Specifically, when a determination is made that a state of reception of the service which is being received by the DAB receiving portion is superior to that

of the service which is being received by the FM receiving portion (or the states of reception are substantially the same), reproduced sound from the DAB receiving portion is selected and output. When a determination has been made that a state of reception of the service which is being received by the FM receiving portion is superior to that of the service which is being received by the DAB receiving portion, reproduced sound from the FM receiving portion is selected and output. The output reproduced sound is amplified by the amplifier 3 so as to be output from the speaker unit 4. The digital broadcast receiver has the above-mentioned schematic structure.

[0026] The operation of the system control unit 1 according to the present invention will now be described. Fig. 2 is a flow chart of the operation of the system control unit 1 in a service follow mode. Note that the foregoing flow chart is executed after input of an instruction to perform the service follow has been made by a user. At this time, the system control unit 1 determines whether or not the DAB receiving portion has been tuned in to any one of the ensembles (step S1).

[0027] When tuning in to any one of the ensembles has been detected, transmitted FIC data can be obtained. Therefore, the FIC data is decoded to extract information about the foregoing protection level and information about the services which can be used by the ensemble, information indicating the linkage among the services, components and sub-channels, PI code information and FI list information to store information in the storage portion 5 (step S2).

[0028] In accordance with obtained information, a service required by the user is selected to output the service from the speaker unit 4 (step S3).

[0029] After sound has been output, the system control unit 1 calculates error ratio BER of each of the two receiving portions in accordance with error information supplied from the DAB receiving portion and the FM receiving portion (step S4). A specific method of calculating the error rate will be described later.

[0030] Then, the error ratio BER of the DAB signal calculated in step S4 is compared with a reference value (step S5). In accordance with information about the protection level obtained and stored in step S2, a reference value for evaluating a state of reception of the selected sub-channel is selected from the corresponding table in the storage portion 5.

[0031] An example of the table constituted in the storage portion 5 is shown in Fig. 3. The table is formed to correspond to the protection level PL. Thus, a reference value corresponding to any one of protection levels 1 to 5 which are regulated by the DAB and which can be selected can be obtained.

[0032] If the protection level of the DAB signal which is being received is 1, corresponding reference value 1 is decided as the reference value for the comparison.

[0033] Then, a comparison is made between the selected reference value and the calculated error ratio BER of the DAB signal. If a determination is made as a result of the comparison that the error ratio BER is smaller the reference value (step S5; small), the state of reception of the DAB station has not deteriorated. Therefore, the operation is returned to step S4 so that the error ratio BER is again calculated in accordance with supplied frame error information (step S4). The error ratio BER is compared with the reference value (step S5). Therefore, when a satisfactory state of reception is realized, the operation circulates in a loop composed of steps S4 and S5.

[0034] If a determination is made as a result of the comparison between the selected reference value and the calculated error ratio BER that the calculated error rate is larger than the reference value (step S5; large), the state of reception of the DAB station has deteriorated. Therefore, the operation proceeds to step S6 so that whether or not service follow is permitted for the RDS station which is broadcasting the same program is determined. Specifically, whether or not the same program is being broadcast in the FM band (step S6) is determined. Then, whether or not an FM-RDS station, the state of reception of which is superior to that of the DAB station, exists is determined (step S7).

[0035] When a determination is made in step S7 that the service follow is permitted, the system control unit 1, in step S8, controls the switching portion 2 to reproduce sound of the RDS station.

[0036] If a determination is made in steps S6 and S7 that an RDS station suitable for the service follow cannot be detected, the operation is returned to step S4 so that the supervisory of the states of reception of the two receiving portions is continued. If the state of reception state of reception of the FM receiving portion has been improved, a determination is made in step S7 that the service follow is permitted. The system control unit 1 controls the switching portion 2 to reproduce sound of the RDS station (step S8).

[0037] The service follow operation is performed as described above. In the present invention, the state of reception of the DAB station is evaluated in step S5 such that an optimum reference value for the evaluation is determined in accordance with information about the protection level of the DAB signal which is being received. In accordance with the reference value and the received DAB signal, the state of reception is determined. Therefore, the annoyance of heard noise and a result of the determination can always be made coincide with each other.

[0038] The process for calculating the error rate in step S4 will now be described. In the present invention, as a parameter for evaluating the states of reception of the DAB signal and the FM signal, error information which is detected by each receiving portion is employed. Specifically, the state of reception of the FM signal which is being received by the FM receiving portion is evaluated in accordance with the block error rate of received RDS data. The state of reception of the DAB signal

which is being received by the DAB receiving portion is evaluated in accordance with the frame error rate of musicam data which constitutes the sub-channel. The foregoing structure is employed on the basis of the following facts.

[0039] Figs. 4A and 4B are diagrams showing RDS data and audio data which is transmitted by the DAB. Fig. 4A shows the structure of audio data for use in DAB, while Fig. 4B shows the structure of RDS data.

[0040] It is a known fact that one group of RDS data is composed of four data blocks composed of offsets A to D. Existence of an error can be detected in each block. One block has a size of 22 ms.

[0041] DAB audio data is based on MPEG1 layer 2. One frame has a size of 24 ms In addition to data of each sub-band, information items including the DAB header, bit allocation information and ScFSI are disposed from the leading end of DAB audio data. Moreover, one frame of DAB audio digital audio contains CRC for detecting an error of each of the DAB header, bit allocation information and ScFSI and CRC for detecting an error of a scale factor. Therefore, the CRC enables existence of an error to be detected in frame (hereinafter called a "block" similarly to that of RDS data) units.

[0042] The applicant of the present invention has paid attention to the fact that the length of one block is the same between the two methods Thus, the block error ratio BER is employed to determine the state of reception of the received DAB signal. On the other hand, the block error rate of RDS digital audio is employed to determine the state of reception of the received FM signal.

[0043] The reason for this will now be described. When the numbers of blocks, which are the denominators of the block error ratios, are made to be substantially the same, an error of the data groups with which each determination has been made and which occurs as time elapses can be reduced to about 10 % between the two method. Therefore, the states of reception can be determined under very close conditions.

[0044] The block error rate and the annoyance of heard noise of RDS data has a proportional relationship. Therefore, the block error rate of RDS data and the state of reception of FM sound can be made accurately correspond to each other.

[0045] Therefore, use of the block error rate enables the evaluation of the two receiving portions which employ the different transmission methods to be performed under very close conditions.

(Second Embodiment)

[0046] The first embodiment has the structure that the block error rates are compared with each other to satisfactorily perform the service follow. In the second embodiment, an estimated error rate with which an error is estimated in accordance with input/output data of a viterbi decoder is employed as a means for detecting the state of reception of the DAB station.

[0047] Fig. 5 is a block diagram showing a digital broadcast receiver adapted to the foregoing method. Note that similar portions to those shown in Fig. 1 are given the same reference numerals and the similar portions are omitted from description.

[0048] The difference from the digital broadcast receiver shown in Fig. 1 lies in a recoding portion 17 provided for the purpose of detecting the state of reception of the DAB station. An output of the viterbi decoder 15 serving as an error correction means is, in the recoding portion 17, again subjected to the convolution-coding process and the punctured process, and then output to a system control unit 31.

[0049] The system control unit 31 makes coincide the positions of data items subjected to the comparison with each other by delaying a signal supplied from the viterbi decoder 15 for a predetermined time. Then, the system control unit 31 subjects delayed data supplied from the viterbi decoder 15 and recoded data to a comparison to detect a bit error of the received DAB signal.

[0050] Then, the detected number of errors is divided by the number of all samples so that an error ratio of the received DAB signal is estimated. Then, an optimum reference value is determined in accordance with protection level information of the received DAB signal. In accordance with the reference value and the calculated error rate, the state of reception of the received DAB signal is determined.

[0051] In accordance with the evaluated state of reception, the system control unit 31 controls an attenuator 32. Specifically, an amount of attenuation is enlarged as the deterioration of the state of reception to vary the output of the speaker unit 4.

[0052] Also the second embodiment is able to evaluate the state of reception by using evaluation criteria which correspond to the protection level of the reference value DAB signal.

(Other Embodiments)

[0053] In the foregoing embodiments, attention has been paid to protection level information transmitted together with audio information. The structure is not limited to this. Audio bit rate information of audio data which constitutes the sub-channel may be used to make a similar table to determine an optimum reference value in accordance with audio bit rate information of the sub-channel which is being selected. That is, the DAB employs MUSICAM as a means for compressing audio data. Since the audio bit rate can be varied from 32 kbit/s to 384 kbit/s, audio bit rate information is extracted from the received DAB signal so as to be used when an optimum reference value is determined. The two methods may be combined with each other to determine the optimum reference value in accordance with protection level information and audio bit rate information.

[0054] An example of a table made in the foregoing case is shown in Fig. 6. Referring to Fig. 6, symbols PL

and BR indicate a protection level and an audio bit rate, respectively. If protection level information and audio bit rate information can be extracted from the received signal, one reference value can be determined by using the foregoing table. If the protection level is 1 and the audio bit rate is 32 kbit/s, a reference value of 1.1 is decided.

[0055] As an alternative to the block error rate of DAB data according to the first embodiment, the estimated error rate according to the second embodiment may be used to determine the state of reception of DAB data. As an alternative to the block error rate of RDS data according to the first embodiment, the intensity of the electric field of the received signal may be used to determine the state of reception of the RDS station.

[0056] As was described above, according to the present invention, protection level information is extracted from a received signal, a reference value corresponding to extracted protection level information is decided, and then a state in which the received signal has been received is determined in accordance with the reference value and the received signal. Therefore, the state of reception can be evaluated by using evaluation criteria corresponding to the protection levels of the received signal.

Claims

1. A digital broadcast receiver for receiving a digital audio broadcast which has a plurality of protection levels and which is able to vary a coding rate of a signal to be transmitted to correspond to each protection level and transmit at least protection level information together with digital audio information, said digital broadcast receiver comprising:

   means for extracting protection level information from a received signal;
   means for deciding a reference value corresponding to extracted protection level information; and
   means for determining a state of reception of the received signal according to the reference value and the received signal.

2. A digital broadcast receiver according to claim 1, further comprising a table for making plural reference values and plural protection levels to correspond to one another, and means for selecting one certain reference value from said table according to extracted protection level information.

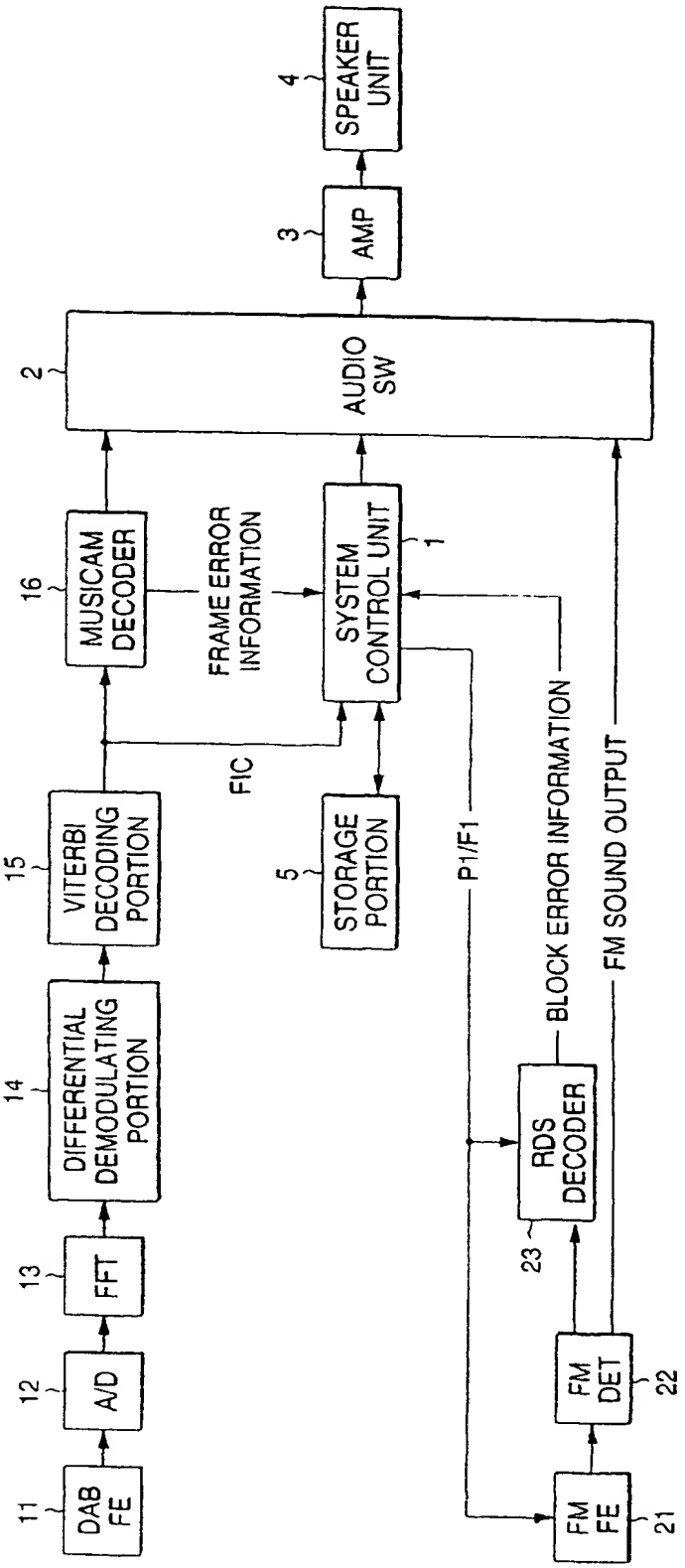
3. A digital broadcast receiver according to claim 1 or 2, wherein the digital audio broadcast is able to furthermore transmit audio bit-rate information of digital audio information, audio bit-rate information is extracted from the received signal by said extracting means, and also extracted bit rate information is used to decide the reference value.

4. A digital broadcast receiver according to claim 3, further comprising a table for making plural reference values, plural protection levels and plural audio bit-rate information items to correspond to one another, and means for selecting one certain reference value from said table according to the extracted protection level information and audio bit-rate information.

5. A digital broadcast receiver comprising:

   an FM receiving portion incorporating an RDS decoder;
   a DAB receiving portion; and
   a control unit for performing control such that an output of the receiving portion in a superior state of reception is selected as an output of said digital broadcast receiver in accordance with a state of reception of an FM signal received by said FM receiving portion and a DAB signal received by said DAB receiving portion;
   wherein said control unit incorporates extracting means for extracting at least protection level information from the received DAB signal; and
   wherein a state of reception of the DAB signal is determined according to extracted protection level information and the received DAB signal.

FIG. 1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SPEAKER UNIT
3
AMP
2
AUDIO SW
16
MUSICAM DECODER
FRAME ERROR INFORMATION
SYSTEM CONTROL UNIT
1
FIC
15
VITERBI DECODING PORTION
5
STORAGE PORTION
P1/F1
BLOCK ERROR INFORMATION
FM SOUND OUTPUT
14
DIFFERENTIAL DEMODULATING PORTION
RDS DECODER
23
13
FFT
12
A/D
FM DET
22
11
DAB FE
FM FE
21

FIG. 2

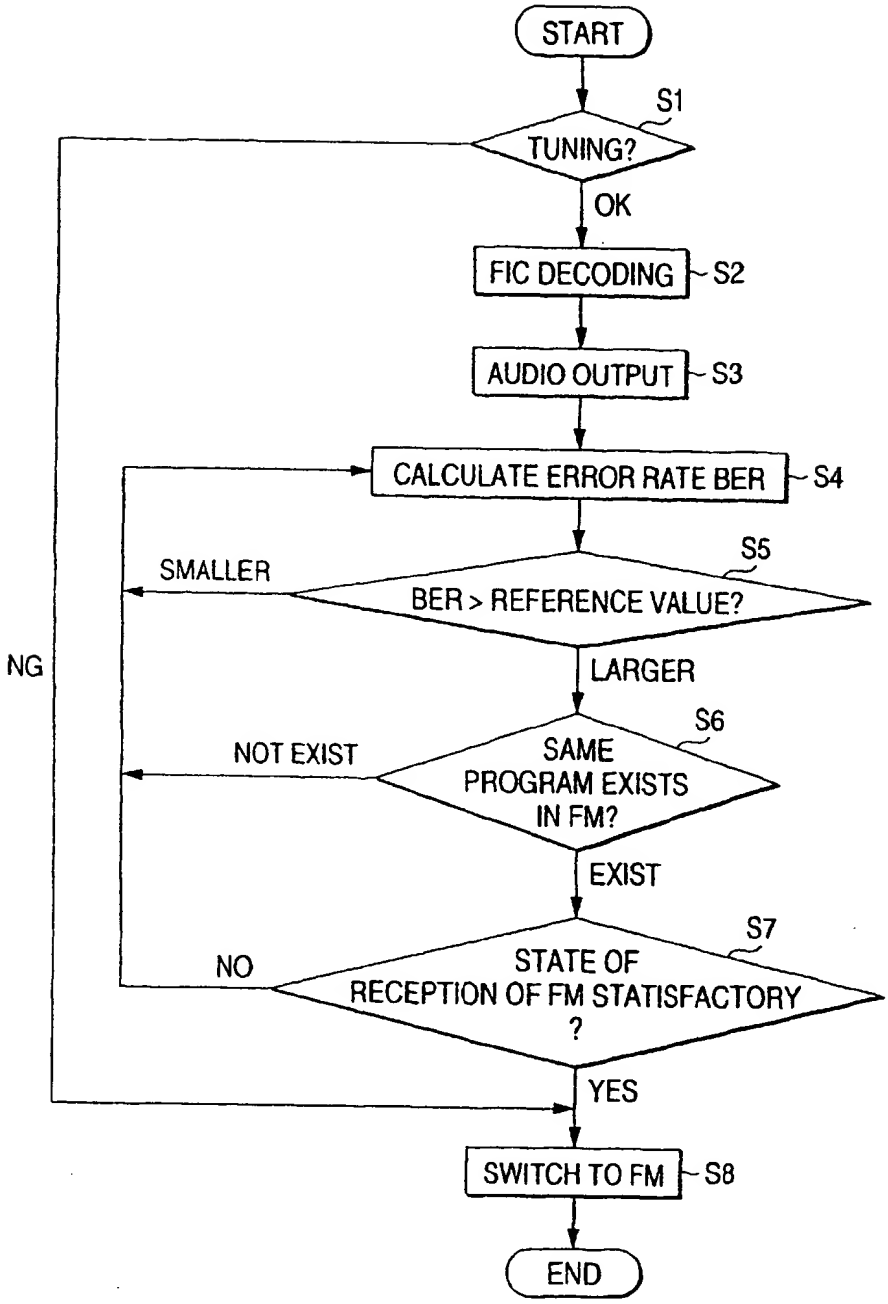

START
S1
TUNING?
OK
FIC DECODING
S2
AUDIO OUTPUT
S3
CALCULATE ERROR RATE BER
S4
S5
SMALLER
BER > REFERENCE VALUE?
NG
LARGER
S6
NOT EXIST
SAME PROGRAM EXISTS IN FM?
EXIST
S7
NO
STATE OF RECEPTION OF FM STATISFACTORY ?
YES
SWITCH TO FM
S8
END

FIG. 3

PL	REFERENCE VALUE
1	REFERENCE VALUE 1
2	REFERENCE VALUE 2
3	REFERENCE VALUE 3
4	REFERENCE VALUE 4
5	REFERENCE VALUE 5

FIG. 4A

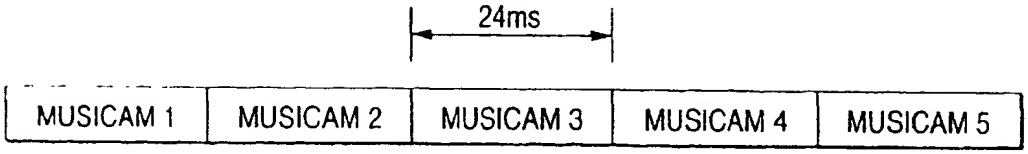


FIG. 4B

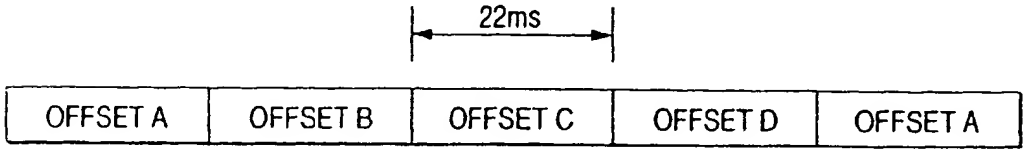


FIG. 5

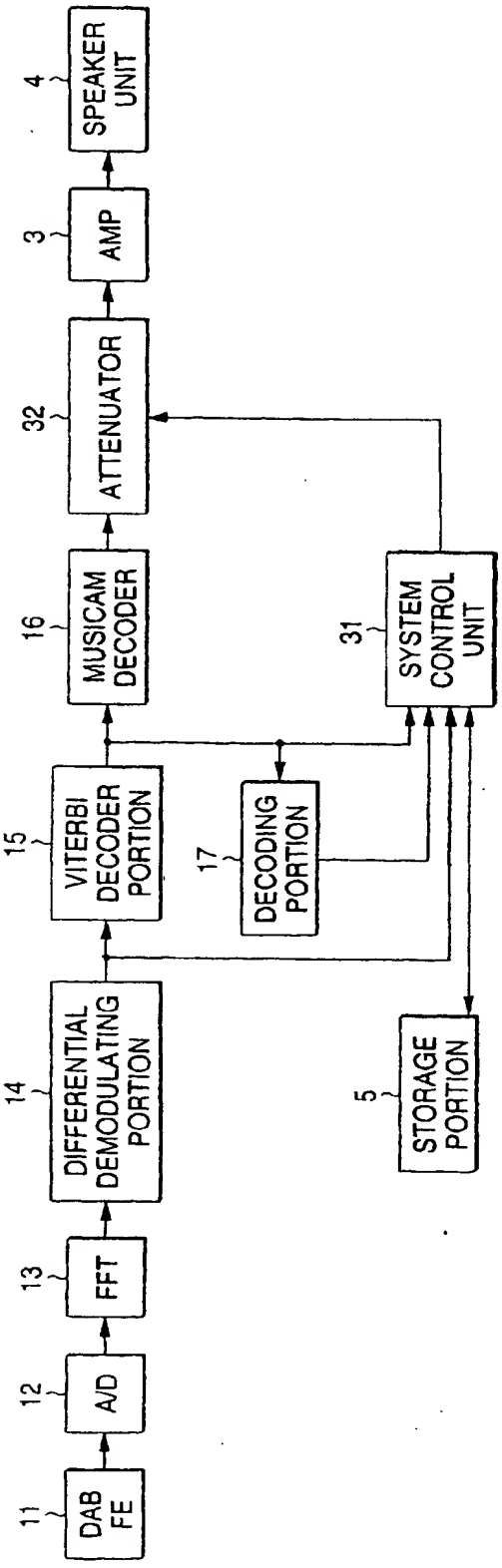
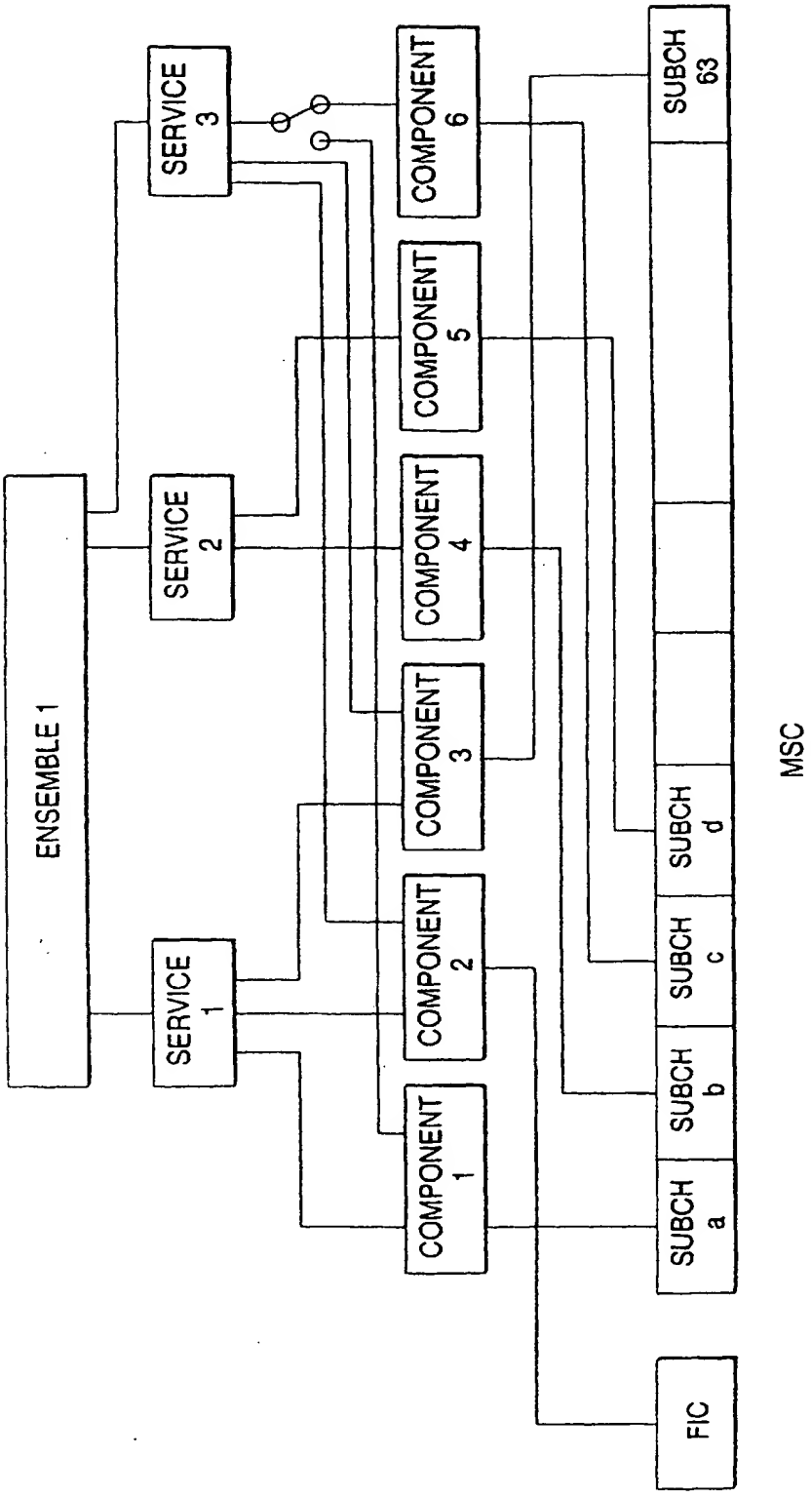

11
DAB FE
12
A/D
13
FFT
14
DIFFERENTIAL DEMODULATING PORTION
15
VITERBI DECODER PORTION
16
MUSICAM DECODER
17
DECODING PORTION
31
SYSTEM CONTROL UNIT
32
ATTENUATOR
3
AMP
4
SPEAKER UNIT
5
STORAGE PORTION

FIG. 6

PL \ BR	32k	----	256k
1	REFERENCE VALUE 1.1	----	REFERENCE VALUE N.1
2	REFERENCE VALUE 2.1	----	REFERENCE VALUE N.2
3	REFERENCE VALUE 3.1	----	REFERENCE VALUE N.3
4	REFERENCE VALUE 4.1	----	REFERENCE VALUE N.4
5	REFERENCE VALUE 5.1	----	REFERENCE VALUE N.5

FIG. 7


ENSEMBLE 1
SERVICE 1
SERVICE 2
SERVICE 3
COMPONENT 1
COMPONENT 2
COMPONENT 3
COMPONENT 4
COMPONENT 5
COMPONENT 6
FIC
SUBCH a
SUBCH b
SUBCH c
SUBCH d
SUBCH 63
MSC

(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 0 961 432 A3

(12) EUROPEAN PATENT APPLICATION

(88) Date of publication A3:
12.09.2001 Bulletin 2001/37

(51) Int Cl.[7]: **H04H 1/00**

(43) Date of publication A2:
01.12.1999 Bulletin 1999/48

(21) Application number: **99304216.7**

(22) Date of filing: **28.05.1999**

(84) Designated Contracting States:
AT BE CH CY DE DK ES FI FR GB GR IE IT LI LU MC NL PT SE
Designated Extension States:
AL LT LV MK RO SI

(30) Priority: **28.05.1998 JP 16418598**

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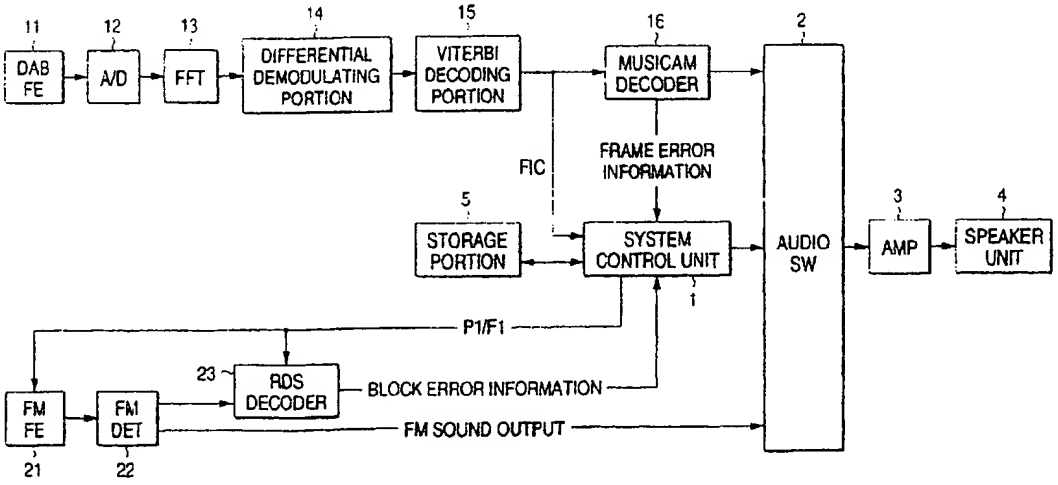
FIG. 1



EP 0 961 432 A3

European Patent Office

EUROPEAN SEARCH REPORT

Application Number
EP 99 30 4216

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.6)
E,L	EP 0 946 011 A (PIONEER ELECTRONIC CORP) 29 September 1999 (1999-09-29) (L:Priority) * the whole document *	1-5	H04H1/00
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Place of search	Date of completion of the search	Examiner
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X : particularly relevant if taken alone
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